EXHIBIT A

IN THE UNITED STATES DISTRICT COURT FOR THE DISTRICT OF DELAWARE

BRIDGESTONE SPORTS CO., LTD., and BRIDGESTONE GOLF, INC.,)
Plaintiffs,)))
v.)
ACUSHNET COMPANY,) C. A. No. 05-132 (JJF)
Defendant.	/) <u>)</u> DEMAND FOR JURY TRIAL
ACUSHNET COMPANY,	
Counterclaim Plaintiff,)
v.)
BRIDGESTONE SPORTS CO., LTD., and BRIDGESTONE GOLF, INC.,)
Counterclaim Defendant.)

ACUSHNET'S OBJECTIONS AND RESPONSES TO BRIDGESTONE'S FIRST SET OF INTERROGATORIES **DIRECTED TO ACUSHNET (NOS. 1-24)**

Pursuant to Rule 33 of the Federal Rules of Civil Procedure, defendant and counterclaim plaintiff Acushnet Company ("Acushnet") hereby responds to the First Set of Interrogatories Directed to Acushnet (Nos. 1-24) ("First Set of Interrogatories") of defendants Bridgestone Sports Co., Ltd. and Bridgestone Golf, Inc. (collectively, "Bridgestone").

GENERAL STATEMENT

In responding to Bridgestone's First Set of Interrogatories, Acushnet does not waive any objection that may be applicable to: (a) the use, for any purpose, of any information or documents given in response to Bridgestone's First Set of Interrogatories; or (b) the admissibility, relevancy, or materiality of any information or documents to any issue in this case.

Bridgestone Patent	Claim No.	Prior Art Related to Validity
	17	Wilson Ultra Tour Balata 90 golf ball manufactured by Wilson Sporting Goods Co.
	The state of the s	Wilson Ultra Tour Balata 100 golf ball manufactured by Wilson Sporting Goods Co.
		• EP 0 633 043 to Bridgestone Sports Co. Ltd., titled "Golf Balls" (published Jan. 11. 1995).
		• United States Patent No. 4,804,189 to William Gobush, titled "Multiple Dimple Golf Ball" (issued Feb. 14, 1989).
5,803,834	1	Wilson Ultra Competition 90 golf ball manufactured by Wilson Sporting Goods Co.
		Wilson Ultra Competition 100 golf ball manufactured by Wilson Sporting Goods Co.
		Precept EV Extra Spin golf ball manufactured by Bridgestone Sports, Ltd.
	2	Wilson Ultra Competition 90 golf ball manufactured by Wilson Sporting Goods Co.
		Wilson Ultra Competition 100 golf ball manufactured by Wilson Sporting Goods Co.
		Precept EV Extra Spin golf ball manufactured by Bridgestone Sports, Ltd.
	4	Wilson Ultra Competition 90 golf ball manufactured by Wilson Sporting Goods Co.
		Wilson Ultra Competition 100 golf ball manufactured by Wilson Sporting Goods Co.
	Account Account and the Constitution of the Co	Precept EV Extra Spin golf ball manufactured by Bridgestone Sports, Ltd.
5,813,924	1	Wilson Ultra Competition 90 golf ball manufactured by Wilson Sporting Goods Co.
	The second secon	Wilson Ultra Competition 100 golf ball manufactured by Wilson Sporting Goods Co.
		Precept EV Extra Spin golf ball manufactured by Bridgestone Sports, Ltd.
		• JP 6-14228 to Bridgestone Sports, titled "Multi-Piece Solid Golf Ball" (published May 24, 1994).

Bridgestone Patent C		Prior Art Related to Validity
Bridgestone satemase		• United States Patent No. 4,858,924 to Saito et al., titled "Solid Golf Ball" (issued Aug. 22, 1989).
		• Reygrande WF 432 golf ball manufactured by Bridgestone Sports, Ltd.
	!	Precept Dynawing Double Cover S+ golf ball manufactured by Bridgestone Sports, Ltd.
		• United States Patent No. 5,779,563 to Yamagishi et al., titled "Multi-Piece Solid Golf Ball" (effective filing date May 13, 1996).
6,634,961	1	• United States Patent No. 6,486,261 to Wu et al., titled "Thin-layer-covered Golf Ball with Improved Velocity."
		• United States Patent No. 6,875,131 to Cavallaro et al., titled "Multi-Layer Golf Ball" (effective filing date Mar. 14, 2001).
	The state of the s	• United States Patent No. 6,162,135 to Bulpett et al., titled "Low Compression, Resilient Golf Balls Including an Inorganic Catalyst and Methods for Making the Same" (issued Dec. 19, 2000).
	3	• United States Patent No. 6,486,261 to Wu et al., titled "Thin-layer-covered Golf Ball with Improved Velocity."
		• United States Patent No. 6,875,131 to Cavallaro et al., titled "Multi-Layer Golf Ball" (effective filing date Mar. 14, 2001).
		• United States Patent No. 6,162,135 to Bulpett et al., titled "Low Compression, Resilient Golf Balls Including an Inorganic Catalyst and Methods for Making the Same" (issued Dec. 19, 2000).
	4	• United States Patent No. 6,486,261 to Wu et al., titled "Thin-layer-covered Golf Ball with Improved Velocity."
	or and the same of	• United States Patent No. 6,875,131 to Cavallaro et al., titled "Multi-Layer Golf Ball" (effective filing date Mar. 14, 2001).
		• United States Patent No. 6,162,135 to Bulpett et al., titled "Low Compression, Resilient Golf Balls Including an Inorganic Catalyst and Methods for Making the Same" (issued Dec. 19, 2000).

Bridgestone Patent Claim	ı No.	Prior Art Related to Validity
2.	ti	United States Patent No. 6,390,935 to Kazushige Sugimoto, tled "Three-Piece Solid Golf Ball" (effective filing date Oct. 7, 1999).
	t	United States Patent No. 6,465,578 to Bissonnette et al., itled "Low Compression, Resilient Golf Balls Including an Organosulfur Catalyst and Method for Making Same" (effective filing date Dec. 24, 1998).
		• United States Patent No. 5,252,652 to Egashira et al., titled "Solid Golf Ball" (issued Oct. 12, 1993).
	e belle and a second of the se	• United States Patent No. 4,556,220 to Tominaga et al., titled "Solid Golf Balls" (issued Dec. 3, 1985).
	And the state of t	• United States Patent No. 4,722,977 to Heinz Fischer, titled "Process and Composition for Viscosity Degradation of Diene Rubbers" (issued Feb. 2, 1988).
		• H. Fries et al. "Mastication of Rubber," Vol. 55, Rubber Chemistry and Technology, pp. 309-327.
6,780,125	2	• United States Patent No. 5,779,563 to Yamagishi et al., titled "Multi-Piece Solid Golf Ball" (issued Jul 14, 1998).
		• JP 09-056848 to Bridgestone Sports, Ltd., titled "Multipiece Solid Golf Ball" (published Mar. 4, 1997).
		• WO 97/09093 to Acushnet Company, titled "Enhanced Lofting Golf Balls" (published Mar. 13, 1997).
		Altus Newing Massy golf ball manufactured by Bridgestone Sports, Ltd.
		Precept Dynawing Double Cover S+ golf ball manufactured by Bridgestone Sports, Ltd.

Ball" (issued Dec. 24, 1996).

• United States Patent No. 5,586,950 to Endo, titled "Golf

Bridgestone Patent	Claim No.	Prior Art Related to Validity
B	10	• United States Patent No. 5,779,563 to Yamagishi et al., titled "Multi-Piece Solid Golf Ball" (issued Jul 14, 1998).
		• JP 09-056848 to Bridgestone Sports, Ltd., titled "Multipiece Solid Golf Ball" (published Mar. 4, 1997).
		• WO 97/09093 to Acushnet Company, titled "Enhanced Lofting Golf Balls" (published Mar. 13, 1997).
	and the state of t	Altus Newing Massy golf ball manufactured by Bridgestone Sports, Ltd.
		Precept Dynawing Double Cover S+ golf ball manufactured by Bridgestone Sports, Ltd.
		• United States Patent No. 5,009,428 to Yamagishi et al., titled "Golf Ball" (issued Apr. 23, 1991).
		• United States Patent No. 5,024,444 to Yamagishi et al., titled "Golf Ball" (issued Jun. 18, 1991).
	And the second s	• United States Patent No. 5,033,750 to Yamagishi et al., titled "Golf Ball" (issued Jul. 23, 1991).
	11	• United States Patent No. 5,779,563 to Yamagishi et al., titled "Multi-Piece Solid Golf Ball" (issued Jul 14, 1998).
***		• JP 09-056848 to Bridgestone Sports, Ltd., titled "Multipiece Solid Golf Ball" (published Mar. 4, 1997).
	Miles de Artico	• WO 97/09093 to Acushnet Company, titled "Enhanced Lofting Golf Balls" (published Mar. 13, 1997).
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	Andrew Control of the	• United States Patent No. 5,024,444 to Yamagishi et al., titled "Golf Ball" (issued Jun. 18, 1991).
	- Annual Principal Control of the Co	• United States Patent No. 5,033,750 to Yamagishi et al., titled "Golf Ball" (issued Jul. 23, 1991).
	13	• United States Patent No. 5,779,563 to Yamagishi et al., titled "Multi-Piece Solid Golf Ball" (issued Jul 14, 1998).
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		• United States Patent No. 5,033,750 to Yamagishi et al., titled "Golf Ball" (issued Jul. 23, 1991).		

Acushnet also refers to any and all documents that were cited or in any way referred to during prosecution of the respective Bridgestone patents-in-suit and/or any continuations, divisionals, continuation-in-parts, reissues, and/or any foreign counter part applications to the Bridgestone patents-in-suit as including other prior art documents that affect or relate to the validity of the Bridgestone patents-in-suit.

Acushnet reserves the right to supplement this response if additional information becomes available.

Interrogatory No. 6:

it seeks information that is subject to the attorney-client privilege and/or attorney work-product privilege.

Without waiver and subject to these objections, Acushnet identifies Jeff Dalton of the Acushnet Company, located at 333 Bridge Street, Fairhaven, Massachusetts 02719-0965 as a person having knowledge of the testing of the Bridgestone products.

As To Objections:

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Dated: July 7, 2005

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EXHIBIT B

FULLY REDACTED

EXHIBIT C

5,779,563

United States Patent [19]

Yamagishi et al.

5,779,563

[11] Patent Number: [45] Date of Patent:

Jul. 14, 1998

[54]	MULTI-PIECE SOLID GOLF BALL
	` !
F743	Tananaran Mikarakit Varanalahir Varanahi Kabibaran

Atsustii Nukamura, all of Chichibu. Japan

Assignee: Bridgestone Sports Co., Ltd., Tokyo. Japan

[21] Appl. No.: 796,454

[22] Filed: Feb. 10, 1997

Related U.S. Application Data

[60] Provisional application No. 60/017,271 May 13, 1996.

Foreign Application Priority Data 130) Peb. 9, 1996 (JP) Jap

[51] Int. CL ... _ A63B 37/06; A63B 37/12 [52] U.S. Cl. ... ___ 473/371; 473/373; 473/384 473/374, 373, 473/384, 372, 377, 378 [58] Field of Search

[56] References Cited

U.S. PATENT DOCUMENTS

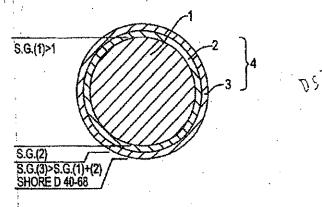
4,714,253 12/1987 Nakahara et al. _ 473/374 X 5,553,252 9/1996 Higuchi et al. ... 5,601,503 2/1997 Yamagishi et al. .

Primary Examiner-George I. Maclo Attorney Agent, or Flrm-Sughrue, Mion. Zinn, Macpeak & Seas, PLLC

ABSTRACT

A multi-piece solid golf ball comprises a solid core and a cover of at least two layers enclosing the core and having a number of dimples in cover outer layer surface. The solid core is formed of a rubber base and has a specific gravity of at least 1.00. The cover is formed of a thermoplastic resin and the cover outer layer has a greater specific gravity than the core or a cover inner layer. The golf ball has an inertia moment (M) within the range given by the following expression: Mor SMSMur wherein Muz=0.08D+84.8 and Mor= 0.08D+77.8 wherein D is a Shore D hardness of the cover. the dimples occupy at least 60% of the ball surface, and Vo is in the range of 0.4 to 0.65. The ball is improved in flight distance, controllability, roll and straight travel upon putting,

5 Claims, 2 Drawing Sheets



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FIG. 1

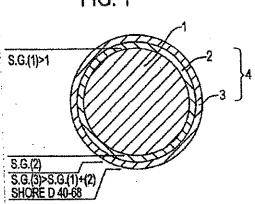
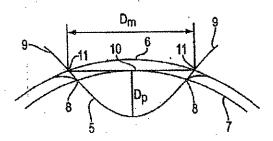


FIG. 2



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FIG. 3

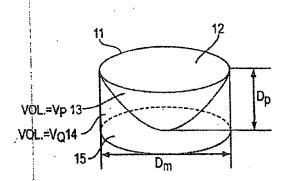
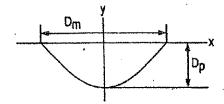


FIG. 4



BSP053583

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1 MULTI-PIECE SOLID GOLF BALL

CROSS REFERENCE TO RELATED APPLICATIONS

This application is an application filed under 35 U.S.C. § 111(a) claiming benefit pursuant to 35 U.S.C. § 119(e) (i) of the filing date of the Provisional application 60/017.271 filed May 13, 1996, pursuant to 35 U.S.C. | 111(b).

BACKGROUND OF THE INVENTION

This invention relates to a multi-piece solid golf ball which is improved in flying distance, controllability, roll and straight travel upon putting as well as restriction and durability.

2. Prior Art

Many covers of gold balls used in the art are composed mainly of losomer resins and have a specific gravity of about 20.96. In order that solid golf balls be unable in competitions. they must meet the requirements prescribed in the Rules of Golf (R&A) and be minufactured to a weight of not greater than 45.93 grams and a diameter of not less than 42.67 mm. Therefore, golf balls obtained using cover stocks composed 25 mainly of lossomer resins will have an inertia moment within a certain range.

The inertia moment of a golf ball largely affects the flight trajectory, flight distance, and control of the ball. In general, an increased inertia moment permits the golf ball to follow 30 an clongued trajectory because the spin attenuation rate of the golf ball in flight is reduced so that the spin is maintained when the ball descends past the maximum abitude. Also when his on the green with a putter, the ball will go straight and roll well. For these reasons, several proposals have been as made on golf balls to impart a greater inertia moment

For example, Japanese Pat, application Kokai (IP-A) No. 277.312/1994 proposes a solid golf ball which is made from an lonomer resin base having titanium white and barium 40 sulfate blended therein so that the ball may have a prester

This proposal, however, suffers from the problems that the golf ball can be scraped and chafed upon iron shots because the cover formed thereon contains much fillers such as 45 titanium white and barium sulfate and that the ball cannot travel a satisfactory distance because the large filler content deteriorates the restitution of the cover.

SUMMARY OF THE INVENTION

An object of the invention is to provide a multi-piece solid An object of the invention is to provide a musti-spece solid golf ball having a cover which has an optimum inertia moment for a certain hardness of a cover outermost layer and an optimum dimpile pattern so that the ball is improved in flying distance, controllability, straight travel and roll upon putting as well as dutability.

Making extensive investigations to attain the above object, the inventors have found that a multi-piece solid golf ball having a cover of at least two layers is improved in flying distance, controllability, roll and straight travel upon putting on the green as well as restitution and cover data bility against iron shots when the core is formed to a specific gravity of 1.00 or higher using a rubber base material, the cover outer layer is formed to a greater specific gravity than 65 the core, the ball has an inectia moment (M) within the range given by the following expression:

Max SMSM₁₂

wherein More-0.08D+84.8 and More-0.08D+77.8 wherein D is a Shore D hardness of a thermoplastic resin of which the cover outer layer is made, that is, an inertia moment is selected in accordance with a cover outer layer hardness. dimples occupy at least 50% of the ball surface, and Vo which is the ratio of the volume of the dimple space below a plane chromacribed by the dimple edge to the volume of a cylinder whose bottom is the plane and whose height is the maximum depth of the dimple from the bottom is in the range of 0.4 to 0.65, and preferably, the core hardness, an index (Dst) of overall dimple surface area given by the following expression:

wherein R is a ball radius. Nk is the number of dimples k. and Vo is as defined above, and the cover outer layer hardness are optimized, and advantageously in this embodiment, the cover outer layer is formed of a thermoplastic polysrethaus clastomer.

Accordingly, the present invention provides a multi-piece solid golf ball comprising a solid core and a cover of at least two layers enclosing the core and having a number of dimples in the surface of a cover outer layer, wherein said solid core is formed of a rubber base and has a

specific gravity of at least 1.00,

said cover is formed of a thermoplastic resin and the cover outer layer has a greater specific gravity than the core and a cover inner layer.

the golf ball has an inertia moment (M) within the range given by the following expression:

M...SMSM...

wherein Moz=0.08D+84.8 and Moz=0.08D+77.8 wherein D is a Shore D hardness of the cover.

the dimples occupy at least 60% of the ball surface.

and Vo which is the ratio of the volume of the dimple space below a plane circumscribed by the dimple edge to the volume of a cylinder whose bottom is the plane and whose height is the maximum depth of the diraple from the bottom is in the range of 0.4 to 0.65.

BRIEF DESCRIPTION OF THE DRAWINGS

PIG. 1 is a cross-sectional view of a golf ball according to one embodiment of the invention;

PIG. 2 is a schematic view (cross-sectional view) of a dimple illustrating how to calculate V_o.

FiG. 3 is a perspective view of the same dimple. FIG. 4 is a cross-sectional view of the same dimple.

DETAILED DESCRIPTION OF THE INVENTION

The present invention is described below in further detail. As shown in FIG. 1, the multi-piece solid golf ball of the invention comprises a solid core I formed of a rubber base and a cover 4 on the core consisting of two layers, an inner layer 2 and an outer 3. The cover 4 consists of two or more

The solid core I should have a specific gravity of at least 1.00, preferably 1.02 to 1.18, more preferably 1.06 to 1.15. The solid core I used hereis may be made of well-known

properly adjusting vulcanizing conditions and formulation.
The core formulation used herein may contain a base rubber. crossitating agent, co-crossitating agent, and ment filler. The base rubber which can be used herein is natural rubber and/or synthetic rubber used in conventional solid golf balls. h is preferred in the practice of the invention to use 1.4-polybutadiene having at least 40% of cit-structure. The polybutadiene may be blended with natural subter, polyisoprene rubber, styrene-butadiene rubber or the like. If desired,

The crostlinking agent which can be used herein is an organic peroxide such as didnnyl peroxide and distantly peroxide, especially dicumyl peroxide. The amount of the crostlinking agent blended is preferably 0.5 to 1.8 parts by weight, especially 0.8 to 1.5 parts by weight per 100 parts by weight per for the base ruther. weight of the base rubber.

The co-crosslinking agent is not critical. Examples are much salts of unsaturated fatry acids, inter alia, zinc and magnesium salts of unsaturated fatry acids having 3 to 8 carbon atoms (e.g., acrylic acid and methacrylic acid), with zinc acrylate being especially preferred. The amount of the 20 co-crosslinking agreet blended is 10 to 40 parts by weight. preferably 15 to 35 parts by weight per 100 parts by weight of the base rubber.

Examples of the inert filler include zinc oxide, barium suifate, silica, calcium carbonate, and zinc carbonate, with zinc oxide being often used. The amount of the filler blended the cardial being often used. The amount of the filler blended is not particularly limited because the amount largely varies with the specific gravity of the core and cover, the weight rescription of the ball, and other factors. Usually, the amount of filler is preferably 5 to 25 parts by weight, more preferably 7 to 20 parts by weight per 100 parts by weight of the base risbber

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A core-forming composition is prepared by knowling the A cure-rounning components in a conventional mixer such above-mentioned components in a conventional mixer such as a Banbury mixer and roll mill, and it is compression or injection modded in a core mold. The molding is then cured by heating at a sufficient temperature for the crosslinking by heating at a sufficient temperature for the crossinshing agent and co-crosslinking agent to function (for example, a temperature of about 130° to 170° C. for a combination of formy) percuide as the crosslinking agent and zine acrylate as the co-crosslinking agent, obtaining a core.

By a proper choice of the type and amount of compound-interpretable corrections constitution amount and

By a proper choice of the type and amount of compound-ing materials, especially crosslinking agent and co-crosslinking agent and vulcanizing conditions, a core having a desired hardness (as expressed by a distortion under a load of 100 kg) can be obtained. Herein, the core is preferably formed to yield a distortion under a load of 100 kg of 2.0 to 5.0 mm, more preferably 3.0 to 4.8 mm. With a distortion falling within this range, sufficient retitution, pleasant bitting feel, and improved scraping resistance are achievable. echievable.

It is noted that the solid core 1 preferably has a diameter of 25 to 41 mm. especially 30 to 40 mm and a weight of 20 to 40 grams, especially 23 to 39.5 grams.

Next, the cover 4 enclosing the above-mentioned solid core I consists of two or more layers and is preferably of a two-layer structure of cover inner and outer layers 2 and 3.

The cover outer layer 3 is formed to a greater specific The cover outer layer 3 is formed to a greater specific gravity than the own 1 and the cover inner layer 2, thereby 60 achieving a high inertia informati and producing a golf ball having excelless flight stability and go-straight stability upon puting. In constrast, the object of the invention is not achievable if the cover outer layer's specific gravity is lower than the specific gravity of the core and cover inner layer. 65 The cover outer layer's except gravity is properly The cover outer layer's specific gravity is properly selected in accordance with the specific gravity of the core and cover

inner layer although it is preferred that the cover outer layer is formed to a specific gravity of at least 1.10, especially 1.10 to 1.25 and the difference of specific gravity between the cover outer layer and the core is 0.01 to 0.15.

Also the cover outer layer hardness is not critical although Also the cover outer layer hardness is not tracest authorga-the cover outer layer is perferably formed to a Shore D hardness of 40 to 68, more preferably 43 to 65. A Shore D hardness of less than 40 would lead to low restitution whereas a Shore D hardness of more than 68 would blant the hitting feet.

The cover outer layer stock used herein is not critical insofat as the cover outer layer is formed to a greater specific gravity than the solid cost and cover inner layer. The cover outer layer may be formed of conventional cover stocks. preferably thermoplastic resins. The thermoplastic resins preferably thermoplastic resins. The thermoplastic resins used herein include thermoplastic polymerhane clastomers, ionomer resins, polyester elastomers, polyanide elastomers, propylene-buildiene copolymers, 1,2-polybutatiene, and propylene-buildiene copolymers, 1,2-polybutatiene, and styrene-batadlene copolymers. These resint may be used alone or in admixture of two or more. It is preferred in the practice of the invention to use thermoplastic polymethene clastomers as a base, for example, PANDEX T-7890 and PANDEX T-1198 (trade name, by Dai-Nihon Int Chamical Industry K.K.). To satisfy the cover's specific gravity defined above, various fillers such as barium sufface, titanium oxide and magnesium stearate may be blended in the thermoplastic resin.

Desirably the cover inner layer has a specific gravity of 0.9 to 1.2 and the cover outer layer has a specific gravity of at least 1.10 as mentioned above. It is also preferred that the means a to an appearance and other specific gravity among the cover owner layers and other layers.

The gage of the cover inner and outer layers is arbitrary although it is preferred that the cover inner layer has a gage of 0.3 to 2.5 ram and the cover outer layer has a gage of 0.3 to 2.5 mm.

Understandably, the golf ball may be manufactured by conventional methods. That is, the golf ball can be obtained hy preforming a pair of half cups of single or multi-layers py compression molding or the like so thereby form a cover of two or more layers. Alternatively, the cover may be formed by injection molding.

Also the golf ball of the invention has an inertia moment (M) in proportion to the cover outer layer hardness (Shore D hardness) within the range given by the following expres-

wherein M_W=0.08D+84.8 and M_{De}=0.08D+77.8 wherein D is a Shore D hardness of the cover outer layer. More specifically, we have found that the inemia moment should fall in an optimum range coordised to the cover hardness. The inertia moment should be greater when the name is tarted but mad not be greater as remained for the band. cover is hard, but need not be greater as required for the hard cover when the cover is soft. This is because a ball with a soft over provides a grater frictional force upon impact and receives more spin whereas a ball with a hard cover provides a loss frictional force and receives less spin. A hard provides a loss increases force and receives tens spin. A made cover ball launched at a low spin race will attenuate its spin fatt and stall on falling if the inertia moment is low laversely, a soft cover ball is mached at a high spin rate will experience less spin attenuation if the inertia moment is too high, so that the ball will rather climb up during flight due to more spin than necessity. In either case, the ball tends to prevel a shorter distance.

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Consequently, the meetia moment of a ball should fall within the above-defined range from the randpoint of imparting excellent characteristics to a ball. An inertia moment below the lower limb of the above-defined range would lead to a stalling trajectory whereas an inertia moment above the upper limit of the above-defined range would lead to a rather climb-up trajectory. In either case, the carry is reduced.

The inertia moment (M) within the above-defined range is 10 determined by the following equation.

$$M = \frac{\pi}{580000} \left\{ (r_1 - r_2) \pm D_1^{-2} + (r_2 - r_3) \pm D_2^{-2} + r_3 D_2^{-2} \right\}$$

r₂, D₃: core specific gravity, diameter

12. Da: intermediate layer specific gravity, diameter

r₃, D₃; cover specific gravity, ball diameter

Like conventional golf balls, the solid golf ball of the 20 invention is formed with a multiplicity of dimples in the surface. The golf ball of the invention is formed with dimples such that provided that the golf ball is a sphere defining a phantom spherical surface, the proportion of the 25 surface area of the phantom spherical surface delimited by the edge of respective discples relative to the overall stafface area of the phantom spherical surface, that is the percent occupation of the ball surface by the disciples is at least 60%.

Note that R is a ball radius, V₀ is as defined above, and preferably 60 to 80%. With a lower disciple occupation, the inertia moment is flight has less of the above-mentioned inertia moment in flight has less of the above-mentioned disciple surface area is useful in optimizing various disciple surface area is useful in optimizing various disciple. effect. The number of dimples is preferably 350 to 500, more preferably 360 to 460. The arrangement of dimples may be as in conventional golf balls. There may be two or more types of dimples which are different in diameter and/or 25 depth. It is preferred that the dimples have a diameter of 2.5 to 4.3 mm and a depth of 0.14 to 0.25 mm.

Morpover, the displies are formed such that V_0 is 0.40 to 0.65, especially 0.43 to 0.60 wherein V_0 is the ratio of the volume of the direpie space below a plane circumscribed by the dimple edge to the volume of a cylinder whose boutom is the plane and whose beight is the maximum depth of the is me planet and whole through if Vo exceeds 0.65, there is a dimple from the beltom. If Vo exceeds 0.65, there is a fixed from the ball climb up and stall, covering a shorter as together with Comparative Examples by way of illustration distance. If Vo is below 0.40, the trajectory would tend to

Now the shape of dimples is described in further detail. In the event that the planar shape of a dimple is circular, as shown in FIG. 2, a phantom sphere 2 having the ball 50 diameter and another phantom sphere 3 having a diameter smaller by 0.16 min than the ball diameter are drawn in conjunction with a dimple 1. The circumference of the other sphere 3 intersects with the dimple 1 at a point 4. A tangent 5 at intersection 4 intersects with the phantom sphere 2 at a point 6 while a scries of intersections 6 define a dimple edge 7. The discple edge 7 is so defined for the reason that otherwise, the exact position of the discple edge cannot be determined because the actual edge of the dimple 1 is rounded. The dimple edge 7 circumscripes a plane 8 (having a diameter Dm). Then as shown in FIGS. 3 and 4, the dimple space 9 located below the plane 8 has a volume Vp. A cylinder 10 whose bottom is the plane 8 and whose height is the maximum depth Dp of the dimple from the bottom or as circular plane 8 has a volume Vq. The ratio Vo of the dimple space volume Vp to the cylinder volume Vq is calculated.

$$V_{p} = \int_{0}^{\frac{Dm}{1}} 2nspds$$

$$V_{Q} = \frac{\pi Dm^{2}Dp}{4}$$

In the event that the planar shape of a dimple is not in the event mat the panner snape or a complete is circular, the maximum diameter or length of a dimple is determined, the plane projected shape of the dimple is assumed to be a circle having a diameter equal to this maximum diameter or length, and V₀ is calculated as above based on this assumption.

based on this assumption.

Furthermore, the golf ball of the invention wherein the number of types of dimples formed in the ball surface is n and the respective types of dimples have a diameter Dmk, a maximum depth Dpk, and a number Nk wherein k=1, 2, 3, n prefers that an index Dst of oversil dimple surface area given by the following equation is at least 4.0, more neglective of the contractive of the preferably 4.0 to 7.0.

parameters so as to allow the guif ball of the invention having the above-mentioned solid core and cover to travel a further distance. When the index Dst of overall dimple surface area is equal to or greater than 4.0, the aerodynamics (flying distance and flight-in-wind) of the golf ball are further enhanced.

The multi-piece solid golf ball of the invention is improved in flying distance, controllability, roll and straight travel upon putting and is less susceptible to scraping upon

EXAMPLE

Examples of the present invention are given below and not by way of limitation.

Examples and Comparative Examples

By kneading a core stock as shown in Table 1 and my ancourg a com stock as shown in Table 1 and valcanizing it in a mold at 160° C. for about 18 minutes, there were prepared solid cores having a weight, diameter, specific gravity and distortion under a load of 100 kg as shown in Table 4.

Goif balls were then obtained by separately kneading an outer cover stock as shown in Table 2 and an inner cover stock as shown in Table 4 and forming them into half cups. stock at mown in cases of any remark around the core, and effecting examplession molding while forming dimples on the outer layer surface in a pattern as shows in Table 3. The parameters and performance properties of the resulting golf bells were examined, with the results shown in Table 4.

The properties of the golf balls reported in Table 4 were evaluated by the following tests.

The diameter of the respective members was an average of diameters measured at arbitrary 5 points. As to weight, the

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ball was disintegrated into the respective members, which were measured for weight. The net weight and volume were calculated therefrom and the specific gravity of the respec-tive members was calculated therefrom. The inertia moment was determined by substituting these values in the following 5 equation.

$M = -\frac{\pi}{580000} \ 1(r_1 - r_2) \nu D_1^2 + (r_2 - r_3) \nu D_2^2 + r_3 D_1^2]$

- $t_1,\,D_1;$ core specific gravity, diameter $t_2,\,D_2;$ intermediate layer specific gravity, diameter
- 13. Dy cover specific gravity, ball diameter

Flying Distance

Using a bitting machine manufactured by True Temper Co., the ball was actually hit at a head speed (HS) of 45 m/sec, with a driver to measure a carry and s-total distance.

Scrape Resistance

Using a swing robot, the ball was hit at arbitrary two positions, once at each position; at a head speed of 38 m/sec, with a sand wedge (SW). The two hit zones were observed 25 to evaluate according to the following criteria.

O: good A: ordinary X: poor

Continuous Durability

Using a flywheel hitting machine, the ball was repeatedly hit at a head speed of 38 m/sec. In terms of the number of hits counted until the ball was broken, evaluation was made according to the following criteria.

O: good A: ordinary X: poor

The ball was actually hit by three professional golfers with a bead speed of 45 to 50 m/sec. Evaluation was made according to the following criteria.

O: soft A: ordinary X: hard

TABLE	1

	****				**********	
Cost formulation (pbw)	Kt	EL	E3	154	CE1	•
Cie-i,4-polytestadiene	100	100	100	100	90	
Polyimpenne Zinc narybin	325	32.5	29.5	25.0	10 27.6	

TABLE 1-continued

		****	***************************************		-	
Care formulation (plow)	BI	162	13	E 4	CE1	
			-		~	
Zac wide	9.2	10.5	8.5	16.2	14.6	
Dicard proside	1.2	1.2	1.2	1.2	1.2	
Zinc salt of pseuschlorothiophenol	0.2	0.2	0.2	0.2		

TABLE 2

Formulation (pbw)	Clones cover type				
	A,	В	ç		
BANDEX T-7890*1	100				
PANDEX T-1198*2		100			
HIMILAN 1706*3			50		
SUREYN #120°4			50		
BaSQ (A.S. 4.47)			20		
BO ₂ (s.g. 4.3)	5.3	5.3	5.3		
Magnesium stearage	0.5	0.5	0.5		
Specific gravity	1.175	1.21	1.13		

*2Dei-Nikon ich Chemical Industry E.K., adipete polyol, thermoplastic

35 *4E. L duPont, Na soft ionomer

TABLE 3.

1 .	Dimple type	Dismeter (mm)	Depth (max)	v.	Namber	Surface cocupation (%)	Det
	1	4.100	0.210	0.500	54	68.7	4.1.37
	·	3.450	0.210	0.500	174		
		3,400	0.210	0.500	132		
6	Ħ	4.150	0.210	0.480	54	70.3	4.061
•		3.850	0.210	0.480	174		
		3.500	0.270	0.480	132		
	孤	3.650	0.193	0.396	156	62.7	1.961
		3.500	0.195	0.390	210		

TABLE 4

		R1	B 2	R3	E4	CB1	CE2	CES
Core	Weight	25.44	29,02	26.19	27.10	33.53	25,44	14.69
	Dimenue	35.50	37.00	36.00	36.00	38.70	35.50	27.70
•	Distriction under 100 kg ford	2.20	2.20	2.50	3.30	2.50	2.20	4.00
	Votage	29,43	26.52	24.43	24.43	30.35	23.43	13.13
	Specific gravity	1.086	1.094	1.032	1.100	1.505	1.086	1.320
lower .	Type 75		2		ь			1
COAR	Wolgh (g)	33.20	35.90	32.84	32.84	_	33.20	34.52
	Discover (mm)	38.75	39.70	38.79	30.75		38.75	36.30
	No hears	7.04	6.24	6.06	6.04	_	7.04	18.29
	Specific gravity (colod.)	1103	1.102	1.103	0.550	-	1.102	L.102
	Not wought	7.76	6.88	6.65	5.74		7.76	20.15
	Claps	1.63	1.35	1.34	1.38		1.63	5.30

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TABLE 4-continued								
Туре	A	٨	В	В	¢	٠.٧	D	
Volume	10.30	8.00	10.30	10.30	18.42	10.30	11.35	
Not weight (g)	12.10	9.40	12.46	12.46	11.77	12.30	10.78	
Specific gravity	1.175	1.175	1,210	1,210	1.130	1.375	0.950	
Gage (state)	1.96	1.50	1.98	1,98	2.00	1.98	2.10	
Shore D hardness	45	45	53	53	55	45	65	
Weight (g)	15,30	45.30	45.30	45,30	45.30	45.30	45.30	
Diameter (non)	42.20	42.70	42.70	42.70	42.70	42,70	42.70	
' 1	85.2	85.0	85.8	84.8	84.5	85.2	80.6	
Men	B8.4	88.4	192	\$9.0	89.2	88.4	90.0	
Mex	81.4	E1.4	82.0	120	\$2.2	81.4	83.0	
	1	11	I	II	1	H)	1	
Carry (m.)	184.5	185.2	385.7	115.5	110.3	177.0	183.0	
Total (m)	3.99.1	199.0	200.0	200.5	195.7	191.5	197.3	
Cer	0	0	0	0	x	0	Ö	
atorite y	٥	0	0	0	4	ō		
-	Ö	0	Ö	Ó	Δ	Ŏ	ô	
	Volume Not weight (g) Specific gravity Gage (mm) Shore D humbers Weight (g) Dismeter (num) Mrs. Mys. Carry (m)	Type A Volume 10.30 Nest weight (g) 15.30 Specific gravity 1.175 Gags (mai) 1.98 Short D huwhater 45.30 Diemeter (mai) 42.20 Mu. 88.4 Mar. 81.4 Carry (m) 184.5 Total (m) 198.5 Co. O	Type A A A Volume 10.30 8.00 Nest weight (g) 12.20 9.40 Specific gravity 1.173 1.175 Gage (mm) 1.98 1.50 Shore D humbates 45 45 Weight (g) 45.30 45.30 Diemeter (mm) 42.20 42.70 85.2 85.0 Mrs. 88.4 88.4 Mys. 11 1 Carry (m) 188.5 183.2 Total (m) 198.5 199.0 O	Type	Type	Type	Type	

HYTREL 4047 HIMELAN 1706 HIMELAN 1605 100

we caum:

1. A multi-piece solid golf ball comprising a solid core

25 solid core experiences a direction of 2.0 to 5.0 mm under a

load of 100 kg.

3. The multi-piece solid golf ball of claim 1 wherein said

load of 100 kg.

3. The multi-piece solid only ball of claim 1 wherein said

solid core experiences a direction of 2.0 to 5.0 mm under a

load of 100 kg.

3. The multi-piece solid only ball of claim 1 wherein said

solid core experiences a direction of 2.0 to 5.0 mm under a

load of 100 kg.

3. The multi-piece solid only ball of claim 1 wherein said layer, wherein

said solid core is formed of a rubber base and has a specific gravity of at least 1.00, said cover is formed of a thermoplastic resin and the cover outer layer has a greater specific gravity than the core and a cover inner layer.

the golf ball has an inertia moment (M) within the range given by the following expression:

wherein M_{DL} =0.08D+84.8 and M_{DL} =0.08D+77.8 wherein D is a Shore D hardness of the cover, the dimples occupy at least 60% of the ball surface; and $V_{\rm o}$ which is the ratio of the volume of the dimple

space below a plane circumscribed by the dimple edge to the volume of a cylinder whose bottom is the plane and whose height is the maximum depth of the dimple from the bottom is in the range of 0.4 to 0.65.

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icad of 100 kg.

3. The multi-piece solid golf bull of claim 1 wherein a types of dimples are formed in the cover, the respective types of dimples have a diameter Dmk, a maximum depth of the dimples is Dpk, and a number of the dimples is Nk whench but 1 2 2 marks. wherein k=1, 2, 3, ..., n, and

an index (Dst) of overall dimple surface area given by the following expression:

wherein R is a ball radius. Nk is the number of dimples k, and V_0 , is as defined above is at least 4.0.

4. The multi-place solid golf ball of claim 1 wherein said

cover outer layer has a Shore D hardness of 40 to 68.

5. The multi-piece solid golf ball of claim 1 wherein said cover outer layer is formed of a polyurethane classumer.



United States Patent [19]

Yamagishi et al.

[11] Patent Number:

5,779,563

[45] Date of Patent:

100

Jul. 14, 1998

[54]	MULTI-P	ECE SOLID GOLF BALL
[75]	Inventors:	Hisashi Yamagishi; Yamshi Ichikawa: Ataushi Nakassara, ali of Chichibu. Japan
[73]	Assignee:	Bridgestone Sports Co., Ltd., Tokyo. Japan
[21]	Appl. No.	: 796 ₄ 854
[22]	Filed:	Feb. 10, 1997
	Re	lated U.S. Application Data
[60]	Provisional	application No. 60/017:271 May 13, 1995.
(30)	Fort	iga Application Priority Data
Pe	b. 9, 1996	(E7) Japan 8-048137
£517	Int. CL*	A63B 37/06; A63B 37/12
		473/371; 473/373; 473/384
		Search 473/374, 373.
-		473/384, 372, 377, 378
[56]		References Cited

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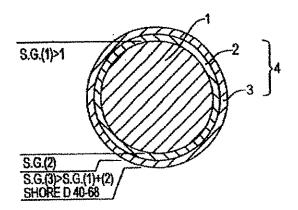
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Primary Examiner-George J. Mwlo Attorney, Agent, or Firm-Sugistic, Mion. Zinn, Macpent & Scas. PLLC

ABSTRACT [57]

A multi-piece solid golf ball comprises a solid core and a cover of at least two layers enclosing the core and having a number of disspice in cover outer layer surface. The solid core is formed of a rubber base and has a specific gravity of at least 1.00. The cover is formed of a thermoplastic resis and the cover outer layer has a greater specific gravity than the core or a cover inner layer. The golf ball has an inertia moment (M) within the range given by the following expression: Mov. SMSM_{IM.} wherein M_{IM}=0.08D+84.8 and M_{DM}=0.08D+77.3 wherein D is a Shore D burdness of the cover. the disspics occupy at least 60% of the ball surface, and \boldsymbol{V}_{o} is in the range of 0.4 to 0.65. The ball is improved in flight distance, controllability, roll and straight travel upon putting.

5 Claims, 2 Drawing Shorts



..., 473/374 X

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FIG. 1

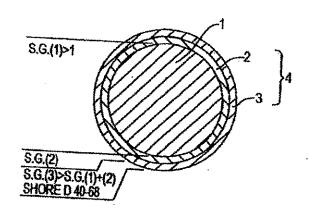
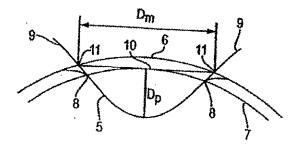


FIG. 2



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FIG. 3

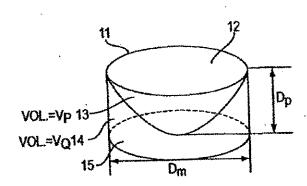
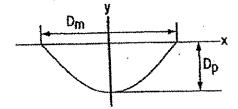


FIG. 4



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MULTI-PIECE SOLID GOLF BALL

CROSS REFERENCE TO RELATED APPLICATIONS

This application is an application filed under 35 U.S.C. § 111(a) claiming benefit pursuant to 35 U.S.C. § 119(e) (i) of the filing date of the Provisional application 60/017.271 filed May 13, 1996, pursuant to 35 U.S.C. § 111(b).

DACKGROUND OF THE INVENTION

I. Field of the Invention

This invention relates to a multi-piece solid golf ball which is improved in flying distance, controllability, roll and straight travel upon putting as well as restitution and durabillity.

2. Prior Art

Many covers of golf balls used in the set are comp mulally of ionomer resins and have a specific gravity of about 20 0.96. In order that solid golf balls be usable in competitions. they must meet the requirements prescribed in the Rules of Golf (R&A) and be manufactured to a weight of not greater than 45.93 grams and a diameter of not less than 42.67 mm. Therefore, golf balls obtained using cover stocks composed 25 mainly of longrour resins will have an inertia moment within èn range.

The inertia moment of a golf ball largely affects the flight trajectory, flight distance, and control of the bell. In general, an increased mentia moment permits the golf ball to follow 30 an clongated trajectory because the spin attenuation rate of the golf ball in flight is reduced so that the spin is maintained when the ball descends past the maximum ablance. Also when hit on the green with a potter, the ball will go straight and roll well. For these reasons, several proposals have been 35 made on golf balls to impart a greater inertia moment

For example, Japanese Pat, application Kokul (P-A) No. 277.312/1994 proposes a solid golf ball which is made from an ionomer resin base having titunium white and burium 40 sulfate blended therein so that the ball may have a greater incatia moment.

This proposal, however, suffers from the problems that the golf ball can be accaped and chafed upon iron shots because the cover formed thereon contains much fillers such as theneum white and busines sulfate and that the ball cannot travel a satisfactory distance because the large filler content deteriorates the restitution of the cover.

SUMMARY OF THE INVENTION

An object of the invention is to provide a multi-piece solid golf ball having a cover which has an optimum inertia moment for a certain bardness of a cover outcomest layer and an optimum dimple patters so that the ball is improved $_{55}$ in flying distance, cosmolishility, straight travel and roll upon putting as well as durability.

Making extensive investigations to attain the above object, the inventors have found that a multi-piece solid golf bell having a cover of at least two layers is improved in so flying distance, controllability, rull and straight travel upon putting on the green as well as restitution and cover durability against iron shots when the core is formed to a specific gravity of 1.00 or higher using a rubber base material, the cover outer layer is formed to a greater specific gravity than as 1.00 perferably 1.02 to 1.18, more preferably 1.06 to 1.15. the core, the ball has an inertia moment (M) within the range given by the following expression:

2

Mar SMSM

wherein M_{DL} =0.08D+84.8 and M_{DL} =0.08D+77.8 wherein D is a Shore D hardness of a thermoplastic resin of which the cover ower layer is made, that is, an incrtia moment is selected in accordance with a cover outer layer hardness. dimples occupy at least 60% of the buil surface, and Vo which is the ratio of the volume of the dimple space below a plane circumscribed by the dimple edge to the volume of a cylinder whose bottom is the plane and whose height is the maximum depth of the dimple from the bottom is in the range of 0.4 to 0.65, and preferably, the core hardness, an index (Dst) of overall dimple surface area given by the following expression:

wherein R is a bull radius, Nk is the number of dimples k. and Vo is as defined above, and the cover outer layer hardness are optimized, and advantageously in this embodiment, the cover outer layer is formed of a thermoplastic polyarethane elastomer.

Accordingly, the present invention provides a multi-piece solid golf ball comprising a solid core and a cover of at least two layers enclosing the core and having a number of dimples in the surface of a cover outer layer, wherein

said solid core is formed of a rubber base and has a specific gravity of at least 1.00.

said cover is formed of a thermoplastic resia and the cover outer layer has a greater specific gravity than the core and a cover laner layer.

the golf ball has an inertia moment (M) within the range given by the following expression:

MOLSMS MOL

whereis Mar. 0.08D+84.8 and Mor. 0.08D+77.8 whereis D is a Shore D hardness of the cover,

the disspice occupy at least 60% of the ball surface. and Vo which is the ratio of the volume of the dimple space below a plane circumscribed by the dimple edge to the volume of a cylinder whose bottom is the plane and whose beight is the maximum depth of the dimple from the bottom 45 is in the range of 0.4 to 0.65.

BRIEF DESCRIPTION OF THE DRAWINGS

FKi. 1 is a cross-sectional view of a golf ball according to one embodiment of the invention;

FIG. 2 is a schematic view (cross-sectional view) of a dimple illustrating how to calculate Vo-

FIG. 3 is a perspective view of the same dimple.

FIG. 4 is a cross-sectional view of the same dimple.

DETAILED DESCRIPTION OF THE INVENTION

The present invention is described below in further detail. As shown in FKG. 1, the multi-piece solid golf ball of the invention comprises a solid core I formed of a rubber base and a cover 4 on the core consisting of two layers, an inner tayer 2 and an outer 3. The cover 4 consists of two or more

The solid core I should have a specific gravity of at least

The solid core I used beccin may be made of well-known materials and formed by conventional techniques while

30

8 -1

properly adjusting vulcanizing conditions and formulation. The core formulation used herein may contain a base rabber, crosslinking agent, co-crosslinking agent, and herein liter filler. The base rubber which can be used herein is natural rubber and/or synthetic rubber used in conventional solid golf balls. It is preferred in the practice of the invention to use 1.4-polybuts/disec having at least 40% of cis-structure. The polyburadiene may be blended with natural rubber, polyisoprene rubber, styrene-buts/diene rubber or the like, if desired.

The crosslinking agent which can be used herein is an organic peroxide such as dicumy! peroxide and di-t-bury! peroxide, especially dicumy! peroxide. The amount of the crosslinking agent blended is preferably 0.5 to 1.8 parts by weight, especially 0.8 to 1.5 parts by weight per 100 parts by weight of the base nubber.

The co-crosslinking agent is not critical. Examples are metal salts of unsaturated fasty acids, inter alia, zinc and magnesium salts of unsaturated fasty acids having 3 to 8 curbon atoms (e.g., acrylic acid and methocrylic acid), with zinc acrylate being especially preferred. The amount of the co-crosslinking agent blended is 10 to 40 parts by weight preferably 15 to 35 parts by weight per 100 parts by weight of the base rubber.

Examples of the inert filter include zinc oxide, benium sulfate, silica, calcium carbonate, and zinc carbonate, with zinc oxide being often used. The amount of the filter blended is not particularly limited because the amount largely varies with the specific gravity of the cure and cover, the weight prescription of the ball, and other factors. Usually, the amount of filter is preferably 5 to 25 parts by weight, more preferably 7 to 20 parts by weight per 100 parts by weight of the base nother.

A core-forming composition is prepared by kneading the above-meationed components in a conventional mixer such as a Banbury mixer and roll mill, and it is compression or injection modded in a core modd. The modding is then cared by heating at a sufficient temperature for the crosslinking agent and co-crosslinking agent to function (for example, a temperature of about 130° to 170° C. for a combination of dicamyly perceible as the crosslinking agent and zine acrylate as the co-crosslinking agent), obtaining a core.

By a proper choice of the type and amount of compounding materials, especially crosslinking agent and co-crosslinking agent and vulcanizing conditions, a core having a desired hardness (as expressed by a distortion under a load of 100 kg) can be obtained. Herein, the core is preferably formed to yield a distortion under a load of 100 kg of 2.0 to 5.0 mm, more preferably 3.0 to 4.8 mm. With a distortion falling within this range, sufficient restitution, pleasant hitting feel, and improved scraping resistance are achievable.

It is noted that the solid core 1 preferably has a diameter of 25 to 41 mm. especially 30 to 40 mm and a weight of 20 to 40 grams, especially 23 to 39.5 grams.

Next, the cover 4 enclosing the above-mentioned solid core 1 consists of two or more layers and is preferably of a two-layer structure of cover inner and outer layers 2 and 3.

The cover ester layer 3 is formed to a greater specific gravity than the core 1 and the cover inner layer 2, thereby so achieving a high inertia moncent and producing a golf ball having excellent flight stability and go-straight stability upon putting, in contrast, the object of the invention is not achievable if the cover outer layer's specific gravity is lower than the specific gravity of the core and cover inner layer. Street outer layer's specific gravity is properly selected in accordance with the specific gravity of the core and cover

inner layer although it is preferred that the cover outer layer is formed to a specific gravity of at least L.10, especially 1.10 to 1.25 and the difference of specific gravity between the cover outer layer and the core is 0.01 to 0.15.

Also the cover outer layer hardness is not critical although the cover outer layer is preferably formed to a Shore D hardness of 40 to 68, more preferably 43 to 65. A Shore D hardness of best than 40 would lead to low restitution whereas a Shore D hardness of more than 68 would blind the hardness feel.

The cover outer layer stock used herein is not critical insofar as the cover outer layer is formed to a greater specific gravity than the solid core and cover laner layer. The cover outer layer may be formed of conventional cover stocks, preferably thermoplastic resins. The thermoplastic resins used herein include thermoplastic polymethane elastomers, propylene-butadiene copolymers. These estimates may be used atome or lie admixture of two or more. It is preferred in the practice of the invention to use thermoplastic polymethane elastomers as a base, for example, PANDEK T-7800 and PANDEK T-1193 (trade name, by Dai-Nihon Ink Chemical Industry K.K.). To satisfy the cover's specific gravity defined above, various fillers such as busium sulfate, titanium oxide and magnetisms stearate may be blended in the thermoplastic resin.

Desirably the cover laner layer has a specific gravity of 0.9 to 1.2 and the cover outer layer has a specific gravity of at least 1.10 as mentioned above. It is the preferred that the cover outer layer has a highest specific gravity among the cover, cover inner and outer layers.

The gage of the cover inner and outer layers is arbitrary although it is preferred that the cover leave layer has a gage of 0.3 to 2.5 mm and the cover outer layer has a gage of 0.3 to 2.5 mm.

Understandably, the golf ball may be manufactured by conventional methods. That is, the golf ball can be obtained by preforming a pair of half cape of single or multi-layers from a cover stock, and encasing the solid core in the cover by compression molding or the lifer to thereby form a cover of two or more layers. Alternatively, the cover may be formed by injection molding.

Also the golf belt of the invention has an inertia moment (M) in proportion to the cover-octer layer hardness (Shore D hardness) within the range given by the following expres-

MpdSMSMcc

wherein Meg=0.08D+84.8 and M_{og}=0.08D+77.8 wherein D is a Shore D hardness of the cover outer layer.

More specifically, we have found that the leastla moment should full in an optionism range correlated to the cover hardness. The inertia moment should be greater when the cover is hard, but need not be greater as required for the hard cover when the cover is soft. This is because a ball with a soft cover provides a greater intelional force upon impact and receives more spin whereas a ball with a hard cover provides a less frictional force and receives less spin. A hard cover ball launched at a low spin rate will attenuate its spin fast and stall on failing if the lacritia moment is low. Inversely, a soft cover ball launched at a high spin rate will experience less spin attenuation if the inertia moment is too high, so that the ball will rather climb up during flight due to more spin than accessity. In either case, the ball tends to travel a shorter distance.

Consequently, the inertia moment of a bail should fall within the above-defined range from the standpoint of imparting excellent characteristics to a ball. An inertia moment below the lower limit of the above-defined range would lead to a stalling trajectory whereas an inertia someont above the upper limit of the above-defined range would lead to a rather climb-up trajectory. In either case, the carry is reduced.

The inertia moment (M) within the above-defined range is 40 determined by the following equation.

$$M = \frac{\pi}{580000} \left[(r_1 - r_2) dD_1^2 + (r_2 - r_3) dD_2^2 + r_3 D_3^2 \right]$$

r₁, D₂; core specific gravity, dismeter

12. Dr. intermediate layer specific gravity, diameter

r₃. D₃: cover specific gravity, ball diameter

Like conventional golf balls, the solid golf ball of the 20 invention is formed with a multiplicity of dimples in the surface. The golf ball of the invention is formed with dimples such that, provided that the golf ball is a sphere defining a phantom spherical surface, the proportion of the surface area of the phantom spherical surface delimited by the edge of respective dimples relative to the overall surface area of the phastom spherical surface, that is the percent occupation of the ball surface by the dissplies is at least 60%. preferably 60 to 80%. With a lower disciple occupation, the 30 inertia moment in flight has less of the above-mentioned effect. The number of dimples is preferably 350 to 500, more preferably 360 to 460. The arrangement of disspics may be as in conventional golf balls. There may be two or more types of damples which are different in diameter and/or 35 depth. It is preferred that the dissples have a diameter of 2.5 to 4.3 mm and a depth of 0.14 to 0.25 mm.

Moreover, the dissples are formed such that V_0 is 0.40 to 0.65, especially 0.43 to 0.60 wherein V_0 is the ratio of the volume of the dissple space below a plane circumscribed by the dissple edge to the volume of a cylinder whose bottom is the plane and whose height is the maximum depth of the dissple from the bottom. If V_0 exceeds 0.65, there is a likelihood that the ball climb op and stall, covering a shorter 45 distance. If V_0 is below 0.40, the majectory would tend to

Now the thape of dimples is described in further detail. In the event that the planar shape of a disspic is circular, as shown in FiG. 2, a phantom sphere 2 having the ball diameter and another phratom sphere 3 having a diameter smaller by 0.16 mm than the ball diameter are drawn in conjunction with a dimple L The circumference of the other sphere 3 intersects with the dimple 1 at a point 4. A tangent 5 at intersection 4 intersects with the phuntom sphere 2 at a point 6 while a series of intersections 6 define a dimple edge 7. The dimple edge 7 is so defined for the reason that otherwise, the exact position of the dimple edge cannot be determined because the setual edge of the disspic I is rounded. The dimple edge 7 circumscribes a place 8 (having a diameter Dan). Then as shown in FKGS. 3 and 4, the dimple space 9 tocated below the plane 8 has a volume Vp. A cylinder 14 whose bottom is the plane 8 and whose height is the transimum depth Dp of the dimple from the bottom or 65 circular plane 5 has a volume Vo. The ratio Vo of the disspic space volume Vp to the cylinder volume Vq is calculated.

$$V_{p} = \begin{cases} \frac{D_{co}}{2} \\ 0 \end{cases} \text{ Include}$$

$$V_{q} = \frac{\pi D m^{2} D p}{4}$$

$$V_{b} = \frac{\sqrt{2}}{4}$$

In the event that the planar shape of a dimple is not circular, the maximum diameter or length of a dimple is determined, the plane projected shape of the dimple is assumed to be a circle having a diameter equal to this assumed matter or length, and V₀ is calculated as above based on this assumption.

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Furthermore, the golf ball of the invention wherein the number of types of dimples formed in the ball surface is a and the respective types of dimples have a diameter Dmk, a maximum depth Dpk, and a number Nk wherein k=1, 2, 3, ..., n prefers that an index Dst of overall dimple surface area given by the following equation is at least 4.0, more preferably 4.0 to 7.0.

Note that R is a ball radius. V₀ is as defined above, and NR is the number of dissples k. The index Dat of overall dimple surface area is useful in optimizing various dissple parameters so as to allow the golf ball of the investion having the above-mentioned solid core and cover to travel a further distance. When the ladex Dat of overall dissple surface area is equal to or greater than 4.0, the aerodynamics (flying distance and flight-in-wind) of the golf ball are further cohmaced.

The multi-piece solid golf ball of the invention is improved in flying distance, conrollability, roll and straight travel upon putting and is less susceptible to scraping upon iron shots.

EXAMPLE

Examples of the present invention are given below together with Comparative Examples by way of illustration and not by way of limitation.

Examples and Comparative Examples

By kneading a core stock as shown in Table 1 and vulcanizing it in a mold at 160° C, for about 18 minutes, there were prepared solid cores having a weight, diameter, specific gravity and distortion under a load of 100 kg as shown in Table 4.

Golf bails were then obtained by separately kneading an outer cover stock as shown in Table 2 and an inner cover stock as shown in Table 4 and forming them into half cups. successively placing the half cups around the core, and effecting compression molding while forming dimples on the outer layer surface in a pattern as shown in Table 3. The parameters and performance properties of the resulting golf balls were examined, with the results shown in Table 4.

The properties of the golf balls reported in Table 4 were evaluated by the following tests.

-Inertia Moment

The diameter of the respective members was an average of diameters measured at arbitrary 5 points. As to weight, the

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ball was disintegrated into the respective members, which were measured for weight. The net weight and volume were calculated therefrom and the specific gravity of the respec-tive members was calculated therefrom. The inertia moment was determined by mastituting these values in the following equation.

 $M = \frac{\pi}{280000} \left[(n-n)nD_1^2 + (n-n)nD_2^2 + nD_2^2 \right]$

- ri. Di: core specific gravity, diameter
- $\mathbf{r}_{\mathbf{z}}, \mathbf{D}_{\mathbf{z}}$ intermediate layer specific gravity, diameter
- r₃, D₃; cover specific gravity, ball dismeter

Flying Distance

Using a hitting machine manufactured by True Temper Co., the ball was actually hit at a head speed (HS) of 45 m/see, with a driver to measure a carry and a total distance.

Scrape Resistance

Using a swing robot, the ball was hit at arbitrary two positions, once at each position, at a head speed of 38 m/sec. with a rand wedge (SW). The two hit zones were observed 25 to evaluate according to the following criteria.

O: good A: ordinary X: poor

Continuous Durability

Using a flywheel kitting machine, the bull was repeatedly hit at a head speed of 38 m/sec. In terms of the number of bits counted until the ball was broken, evaluation was made according to the following criteria.

O: good A: onlinery X: poor

Feeling

The ball was actually hit by three professional golden with a head speed of 45 to 50 m/sec. Evaluation was made according to the following criteria.

O: soft A: ordinary X: bard

\$1,320x*47	

Core formulation (pire)	H1	312	163	154	CEI
Ca-L4-polylestelione Polyimpsen Zinc stryless	100 32.5	196 32.5	100 29.3	100 25,0	90 10 27.0

TABLE 1-continued

5	Core formulation (pbw)	RI	E	£3	154	CED				
	Zas: exide	9.2	30.5	8.5	16.2	14.6				
	Dicumyl permitte	1.2	1.2	1.2	1.2	1,2				
10	Zinc salt of perandianothicplescol	0.2	0.2	0.2	0.2	•				

TABLE 2

.npurts	Other cover type					
Permulation (pb=)	٨	B.	¢			
Pancieck T-7890*1	100	,				
PANDEX T-1198*1		100				
HDELAN 1706*3			50			
SURLYN 8120*4			.50			
BaSO ₄ (a.g. 4.47)			20			
TiO ₂ (e.g. 4.3)	5.3	53	5.3			
Magnesian statesto	0.5	0.5	615			
Specific gravity	1.175	1.21	1.1			

30 "Dai-Miles lisk Chemical Industry K.K., adipute polyet, there polymetimo *2Dul-Ribon link Chemical Industry K.K., udipute polyol, therescoleries

35 ME. E dell'out, Na solt ionomer

TABLE 3

3	Dimple Ope	Dinamics (sam)	Dopta (xxx)	V _o	Number	Stations occupation (%)	Det
•	1	4,100	0.210	0.500	54	63.7	4.137
		3.250	0.210	0.500	374		
		3,400	0.210	0.500	132		
	Ħ	4.130	0.210	0.480	54	70.3	4,061
		3.833	0.210	0.00	174		
		3.500	0.210	0.430	132		
	85 .	3.650	0.195	0.390	1.50	63.7	1361
		3,500	0.195	0.390	210		

TABLE 4

***************************************		Ei	E2	E3	54	CBI	€62	CH3
Core	White	25,44	29:02	26.19	27.10	33.53	25.44	34.69
	Diameter	35.50	37,00	36.00	36.00	38,70	35.50	27.20
	Distortion poder	2.20	2.20	2.60	3.30	2.50	2.70	4.00
	100 kg load							
	Volume	23.A3	26.57	24.43	24.43	30.35	23.43	11.13
	Specific anythy	1.086	1.094	1.077	1109	1.105	1.066	1.370
toner	Type *5				b		*	
CENTER	Weight (g)	33,20	35.20	32.54	32.84	******	33,20	34.57
	Diseases (casa)	38,75	39.70	38.75	38.75		38.75	38.30
	Volume	7.04	6.24	6.04	5.04		7.04	18.20
	Specific energy	1,102	1.102	1.302	0.950		1.102	1.102
	(calcd.)							
_	Not weight	7.76	5.23	6.65	5.74		7.76	20.15
	Gago	1.53	1.35	1.38	1.39	_	1.63	5.30

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liet weight (a)

Specials attents e Li bos

Minght (g)

TABLE 4-continued D 13.35 A 800 9.40 L175 1.50 1030 1246 1,210 1,98 10.30 12.10 N0.00 12.46 1.210 1.94 53 45.30 42.70 85.8 19.6 82.8 1 185.7 200.0 O 10.42 11.77 1.130 2.00 55 45.30 42.70 26.5 19.2 11.30 19.3 195.7 12.10 1.175 1.98 19.78 19.950 2.10 1,175 1,58 45 45.30 42.30 45.30 45.4 41.4 177.0 191.3 0 0 0 45 4530 4270 4330 884 814 8153 1950 0 53 45.30 42.70 84.8 89.6 82.0 8 1155.5 200.5 O 45.00 45.30 42.70 80.5 90.0 83.0 183.0

15 leace cover type		
HYTERL 4047	100	
2004ELAN 1706		30
HEATH AN 1606		50

2. The multi-piece solid golf ball of claim I wherein said

1. A multi-piece solid golf ball comprising a solid core
and a cover of at least two layers enclosing the core and
having a number of distributes in the surface of a cover of a cover of distributes in the surface of a cover of layer, wherein

said solid core is formed of a rubber base and has a specific gravity of at least 1.00.

said cover is formed of a thermoplastic resin and the cover outer layer has a greater specific gravity than the core and a cover inner layer.

the golf belt has so incrtis moment (M) within the range given by the following expression:

M_{PR}SMSM_{IK}

wherein M_{ME}=0.08D+84.8 and M_{DE}=0.08D+77.8 wherein D is a Shore D bardness of the cover.

the disriples occupy at least 60% of the ball surface.

and V_D which is the ratio of the volume of the dimple space below a plane circumscribed by the dimple edge to the volume of a cylinder whose bottom is the plane and whose height is the maximum depth of the dimple 43 from the bottom is in the range of 0.4 to 0.65.

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types of dimples are formed in the cover, the respective types of dimples have a diameter Dusk, a maximum depth of 30 the disspler is Dpk, and a number of the disspler is Nk wherein k-1, 2, 3, ..., a, and

an index (Dat) of overall dimple surface area given by the following expression:

å

wherein R is a ball radius. Nk is the number of dimples k. 40 and Vo. is as defined above is at least 4.0.

4. The multi-piece solid golf half of claim 1 whereis said cover outer layer has a Shore D bardness of 40 to 68.

5. The multi-piece solid golf ball of claim 1 wherein said cover outer layer is formed of a polymethene clustomer.

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Yamagishi et al.

[11] Patent Number:

5,779,563

[45] Date of Patent:

Jul. 14, 1998

[54] [75]	loventors:	ECE SOLID GOLF BALL. Hisashi Yamagishi; Yasushi lehikawa: Atsushi Nakamura, ali of Chichibu, Japan	5,002,281 5,497,996 5,553,852 5,601,503	7/1996 9/1996	Nakahan et al
[73]	Assignce:	Bridgestone Sports Co., Ltd., Tokyo. Japan	Primary Exam Attorney, Ages & Seas, PLLC	nt or Fi	icorge I. Mario inn-Sughrue, Mioa, Zina, Macpeak

[57]

[21] Appl. No.: 796,454

[22] Filed: Feb. 10, 1997

Related U.S. Application Data [60] Provisional application No. 60/017.271 May 13, 1996.

Foreign Application Priority Data [30] Peb. 9, 1996 [JP] Japan [53] Inc. CL6 A63B 37/06; A63B 37/12 473/371: 473/373: 473/384 52] U.S. CL 473/374, 373. [58] Field of Search

[56]

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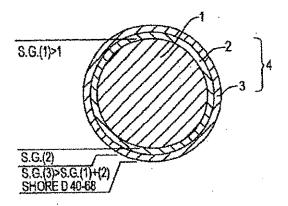
U.S. PATENT DOCUMENTS

473/384, 372, 377, 378

ABSTRACT

A multi-piece solid golf ball comprises a solid core and a cover of at least two layers eaclosing the core and having a number of dimples in cover outer layer surface. The solid core is formed of a rubber base and has a specific gravity of at least 1.00. The cover is formed of a thermoplastic resin and the cover outer layer has a greater specific gravity than the core or a cover inner layer. The golf ball has an inertia moment (M) within the range given by the following expression: $M_{DL} \le M \le M_{UL}$, wherein $M_{UL} = 0.08 D + 84.8$ and $M_{DL} = 0.08 D + 84.8$ and $M_{DL} = 0.08 D + 84.8$ and $M_{DL} = 0.08 D + 84.8$ 0.08D+77.8 wherein D is a Shore D hardness of the cover, the dimples occupy at least 60% of the ball surface, and V is in the range of 0.4 to 0.65. The ball is improved in flight distance, controllability, roll and straight travel upon putting.

5 Chims, 2 Drawing Shrets



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Sheet 1 of 2

FIG. 1

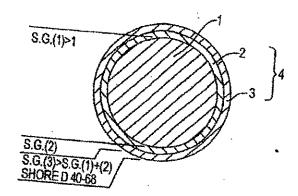
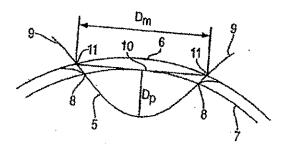


FIG. 2



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FIG. 3

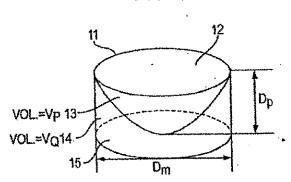
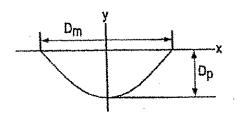


FIG. 4



1 MULTIPIECE SOLD GOLF BALL

CROSS REPERFINCE TO RELATED APPLICATIONS

This application is an application filed under 35 U.S.C. § 11(a) claiming benefit pursuant to 35 U.S.C. § 119(c) (i) of the filing date of the Provisional application 60/017.271 filed May 13, 1996, pursuant to 35 U.S.C. & H1(b).

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a multi-piece solid golf ball which is improved in flying distance, controllability, roll and straight travel upon putting as well as restitution and dura-

2. Prior Art

Many covers of golf balls used in the an are composed majnly of lonomer resins and have a specific gravity of about 20 0.96. In order that solid golf balls be usable in competitions. they must meet the requirements prescribed in the Rules of Golf (R&A) and be manufactured to a weight of not greater than 45,93 grams and a diameter of not less than 42.67 mm. Therefore, golf balls obtained using cover stocks composed mainly of lonomer resias will have an inertia moment within a centain range.

The incrtia moment of a golf ball largely affects the flight trajectory, flight distance, and control of the ball. In general, an increased inenta moment permits the golf ball to follow an elongated trajectory because the spin strenuation rate of the golf ball in flight is refluced so that the spin is maintained when the ball descends nost the maximum abitude. Also when the ball descends past the maximum altitude. Also when hit on the green with a patter, the ball will go straight and roll well. For these reasons, several proposals have been made on golf builts to impart a greater inertia moment

For example, Japanese Pm, application Kokai (IP-A) No. 277.312/1994 proposes a solid golf ball which is made from an ionomer resin base having titanium white and barium 40. suffice blended therein so that the ball may have a greater

This proposal, however, suffers from the problems that the golf ball can be scraped and chafed upon iron shots because the cover formed factors contains much fillers such as situation white and barium sulfate and that the ball cannot travel a satisfactory distance because the large filler content deteriorates the restitution of the cover.

SUMMARY OF THE INVENTION

An object of the invention is to provide a multi-piece solid golf ball having a cover which has an optionen lucrita moment for a certain hardness of a cover outermost layer and an optimum dimple pattern so that the ball is improved in flying distance, cosmoliability, smalght travel and roll opon prating as well as durability.

Making extensive investigations to attain the above object, the inventors have found that a multi-piece solid golf bail having a cover of at least two layers is improved in so hying distance, controllability, roll and straight travel upon putting on the green as well as restitution and cover dura-bility against iron shots when the core is formed to a specific gravity of 1.00 or higher using a rubber base material, the cover outer layer is formed to a greater specific gravity than the core, the ball has an inertia moment (M) within the range given by the following expression:

M_{OL}SMSM_{UL}

wherein M_{UL} =0.08D+84.8 and M_{DL} =0.08D+77.8 wherein D is a Shore D hardness of a thermoplastic resis of which the cover outer layer is made, that is, an inertia moment is selected in accordance with a cover outer layer hardness dimples occupy at least 60% of the ball surface, and V₀ which is the ratio of the volume of the dimple space below a plane circumscribed by the dimple edge to the volume of a cylinder whose bottom is the plane and whose height is the maximum depth of the dimple from the bottom is in the range of 0.4 to 0.65, and preferably, the core hardness, an index (Dst) of overall dimple surface area given by the following expression:

$$D_{eff} = \frac{\sum_{k=1}^{p} |(D_{eff})^2 + D_{eff}|) |(V_{eff})^2 + D_{eff}|}{4R^4}$$

wherein R is a ball radius. Nk is the number of diraples k. and Vo is as defined above, and the cover outer layer hardness are optimized, and advantageously in this embodiment, the cover outer layer is formed of a thermo-plastic polyurchane elastomer.

Accordingly, the present invention provides a multi-piece solid golf ball comprising a solid core and a cover of at least two layers enclosing the core and having a number of dimples in the surface of a cover outer layer, wherein said solid core is formed of a rubber base and has a specific or said solid core in a layer.

specific gravity of at least 1.00.

said cover is formed of a thermoplastic resin and the cover ouser layer has a greater specific gravity than the cose and a cover inner layer, the golf ball has an inertia moment (M) within the range

given by the following expression:

H_{ru}SMSM_{ov}

whereis Mor=0.08D+84.8 and Mor=0.08D+77.8 whereis D is a Shore D hardness of the cover,

the dimples occupy at least 60% of the ball surface. and V_0 which is the ratio of the volume of the disciple space below a plane circumscribed by the disciple edge to the volume of a cylinder whose bottom is the plane and whose height is the maximum depth of the dimple from the bottom is in the range of 0.4 to 0.65.

ERHIF DESCRIPTION OF THE DRAWINGS

FIG. I is a cross-sectional view of a golf ball according to one embodiment of the invention;

PIG. 2 is a schematic view (cross-sectional view) of a dimple illustrating how to calculate V₀.

FKG. 3 is a perspective view of the same dimple. PIG. 4 is a cross-sectional view of the same dimple.

DETAILED DESCRIPTION OF THE INVENTION

The present invention is described below in further detail. As shown in FIG. 1, the multi-piece solid golf ball of the invention comprises a solid core I formed of a rubber base and a cover 4 on the core consisting of two layers, an inner layer 2 and an order 3. The cover 4 consists of two or more layers.

The solid core I should have a specific gravity of at least 1.00, preferably 1.02 to 1.18, more preferably 1.06 to 1.15.

The solid core I used herein may be made of well-known materials and formed by conventional techniques while properly adjusting vulcanizing conditions and formulation. The core formulation used herein may contain a base rubber, crosslinking agent, co-crosslinking agent, and inert filler. The base rubber which can be used herein is natural rubber and/or-synthetic rubber used in conventional solid golf balls. It is preferred in the practice of the invention to use 1.4-polybutadiene having at least 40% of cis-structure. The polybutadiene may be blended with unutual rubber, polylsoprene rubber, styrene-butadiene rubber or the like, if desired,

The crosslinking agent which can be used herein is an organic peroxide such as dicumyl peroxide and dist-buryl peroxide, especially dicumyl peroxide. The amount of the crosslinking agent bleaded is preferably 0.5 to 1.8 parts by weight, especially 0.8 to 1.5 parts by weight per 100 parts by weight of the base rubber.

The co-crosslinking agent is not critical. Examples are metal salts of unsaturated fatty acids, inter alia, zinc and magnesium salts of unsaturated fatty acids having 3 to 8 carbon atoms (e.g., acrylic acid and methacrylic acid), with zinc acrylate being especially preferred. The amount of the co-crosslisting agent blended is 10 to 40 parts by weight, preferably 15 to 35 parts by weight per 100 parts by weight of the base nubber.

Examples of the inert filler include zinc oxide, barium sulfate, silica, calcium curbonate, and zinc carbonate, with zinc oxide being often used. The amount of the filler blended is not particularly limited because the amount largely varies with the specific gravity of the core and cover, the weight prescription of the ball, and other factors. Usually, the amount of filler is preferably 5 to 25 parts by weight, more preferably 7 to 20 parts by weight per 100 parts by weight of the base nubbet.

A core-forming composition is prepared by kneading the above-mentioned components in a conventional mixer such as a Banbury mixer and roll mill, and it is compression or injection motied in a core mold. The modding is then cured by heating at a sufficient temperature for the crosslinking agent no function (for example, a temperature of about 130° to 170° C, for a combination of dicumy) peroxide as the crosslinking agent and zinc acrylate as the co-crosslinking agent, obtaining a core.

By a proper choice of the type and amount of compounding materials, especially crosslinking agent and co-crosslinking agent and vulcinizing conditions, a core having a desired hardness (as expressed by a distortion under a load of 100 kg) can be obtained. Herein, the core is preferably formed to yield a distortion under a load of 100 kg of 2.0 to 5.0 mm, more preferably 3.0 to 4.8 mm. With a distortion falling within this range, sufficient restitution, pleasant liking feel, and improved scraping resistance are achievable.

It is noted that the solid core 1 preferably has a diameter of 25 to 41 mm. especially 30 to 40 mm and a weight of 20 to 40 grams, especially 23 to 39.5 grams.

Next, the cover 4 enclosing the above-mentioned solid core I consists of two or more layers and is preferably of a two-layer structure of cover inner and outer layers 2 and 3.

The cover outer layer 3 is formed to a greater specific gravity than the core 1 and the cover inner layer 2, thereby 60 achieving a high inertia moment and producing a gelf ball having excellent flight stability and go-straight stability upon patting. In contrast, the object of the invention is not achievable if the cover outer layer's specific gravity is lower than the specific gravity of the core and cover inner layer. 6: The cover outer layer's specific gravity is properly selected in accordance with the specific gravity of the core and cover

inner layer although it is preferred that the cover outer layer is formed to a specific gravity of at least 1.10, especially 1.10 to 1.25 and the difference of specific gravity between the cover outer layer and the core is 0.01 to 0.15.

Also the cover outer layer hardness is not critical although the cover outer layer is preferably formed to a Shore D hardness of 40 to 68, more preferably 43 to 65. A Shore D hardness of less than 40 would lead to low restitution whereas a Shore D hardness of more than 68 would blust the hirting feel.

The cover outer layer stock used herein is not critical insofar as the cover outer layer is formed to a greater specific gravity than the solid core and cover inner layer. The cover outer layer may be formed of conventional cover stocks, preferably thermoplastic resins. The thermoplastic resins used herein include thermoplastic polyumethane clustomers, ionomer resins, polyester clustomers, polyamide clustomers, propytiene-butadiene copolymers. 1.2-polybutadiene, and styrene-butadiene copolymers. 1.2-polybutadiene, and styrene-butadiene copolymers. These resins may be used alone or in admixture of two or more. It is preferred in the practice of the invention to use thermoplastic polyumethane clustomers as a base, for example. PANDEX T-1898 and PANDEX T-1898 (trade name, by Dai-Nihon Ink Chemical Industry K.K.). To satisfy the cover's specific gravity defined above, various fillers such as barium sulfate, titanium oxide and magnesium steamte*may be blended in the thermoplastic resis.

Desirably the cover inner layer has a specific gravity of 0.9 to 1.2 and the cover outer layer has a specific gravity of at least 1.10 as mentioned above. It is also preferred that the cover outer layer has a highest specific gravity among the core, cover inner and outer layers.

The gage of the cover inner and outer layers is arbitrary atthough it is perferred that the cover inner layer has a gage of 0.3 to 2.5 mm and the cover outer layer has a gage of 0.3 to 2.5 mm.

Understandably, the gelf ball may be manufactured by conventional methods. That is, the gelf ball can be obtained by preforming a pair of half caps of single or multi-layers from a cover stock, and encasing the solid core in the cover by compression molding or the like to thereby form a cover of two or more layers. Alternatively, the cover may be formed by injection molding.

Also the golf ball of the invention has an inertia moment (M) in proportion to the cover outer layer hardness (Shore D hardness) within the range given by the following expression:

М_{ос}биби_{се}

wherein M_{1/2}=0.08D+84.8 and M_{2/2}=0.08D+77.8 wherein D is a Shore D hardness of the cover outer layer.

More specifically, we have found that the inertia moment should fall in an optimum range correlated to the cover hardness. The inertia moment should be greater when the cover is hard, but need not be greater as required for the hard cover when the cover is soft. This is because a ball with a soft cover provides a greater frictional force upon impact and receives more spin whereas a ball with a hard cover provides a less frictional force and receives less spin. A hard cover ball launched at a low spin rate will attenuate its spin fast and stall on falling if the inertia moment is low. Inversely, a soft cover ball launched at a high spin rate will experience less spin attenuation if the inertia moment is too high, so that the ball will suffice climb up during flight due to more spin than necessity. In either case, the ball tends to travel a shorter distance.

The inertia moment (M) within the above-defined range is to determined by the following equation.

$$H = \frac{\pi}{2} \{(n - n)dn^2 + (n - n)dn^2 + ndn^2\}$$

r1. Di: core specific grayity, diameter

ro. Do: intermediate layer specific gravity, diameter

13. D₃: cover specific gravity, ball dismeter

Like conventional golf balls, the solid golf ball of the 20 invention is formed with a multiplicity of dimples in the surface. The golf ball of the invention is formed with displies such that, provided that the golf ball is a sphere defining a phantom spherical surface, the proportion of the 25 surface area of the phantom spherical surface delimited by the edge of respective disopies relative to the overall surface area of the plasmom spherical surface, that is the percent occupation of the ball surface by the dimples is at least 60%. preferably 60 to 80%. With a lower dimple occupation, the 30 inertia moment in flight has less of the above-mentioned effect. The number of dimples is preferably 350 to 500, more preferably 360 to 460. The arrangement of dimples may be as in conventional golf balls. There may be two or more types of dimples which are different in diameter and/or 35 depth. It is preferred that the dimples have a diameter of 25 to 43 mm and a depth of 0.14 to 0.25 mm.

Moreover, the diaples are formed such that V_{α} is 0.40 to 0.65, especially 0.43 to 0.60 wherein Vo is the ratio of the volume of the dimple space below a plane circumscribed by the dimple edge to the volume of a cylinder whose bottom is the plane and whose beight is the maximum depth of the dimple from the bottom. If Vo exceeds 0.65, there is a likelihood that the ball climb up and stall, covering a shorter 45 distance. If Vo is below 0.40, the trajectory would tend to descend

Now the shape of dimples is described in further detail. In the event that the planar shape of a dimple is circular, as shown in FIG. 2. a phantom sphere 2 having the ball 50 diameter and another phantom sphere 3 having a diameter smaller by 0.16 mm than the ball diameter are drawn in conjunction with a dimple L. The circumference of the other sphere 3 intersects with the direple 1 at a point 4. A tangent 5 at intersection 4 intersects with the phantom sphere 2 at a point 6 while a series of intersections 4 define a dimple edge 7. The dimple edge 7 is so defined for the reason that otherwise, the exact position of the dimple edge cannot be determined because the actual edge of the dimple 1 is rounded. The dimple edge 7 circumscribes a plane 8 (having a diameter Dm). Then as shown in FIGS. 3 and 4, the dimple space 9 located below the plane 8 has a volume Vp. A cylinder 14 whose bottom is the plane 8 and whose height is the maximum depth Dp of the dimple from the bottom or 55 circular place 8 has a volume Vq. The ratio Vo of the dimple space volume Vp to the cylinder volume Vq is calculated

$$V_{p} = \int_{0}^{\infty} \frac{D_{pq}}{2\pi c_{pq} dx}$$

$$V_{q} = \frac{V_{qq}}{2}$$

$$V_{q} = \frac{V_{qq}}{2\pi c_{pq}}$$

In the every that the planar shape of a dimple is not circular, the maximum diameter or length of a dimple is determined, the plane projected shape of the dimple is assumed to be a circle having a diameter equal to this maximum diameter or length, and Yo is calculated as above based on this assumption.

Furthermore, the golf ball of the investion wherein the number of types of dimples formed in the ball surface is a and the respective types of dimples have a diameter Dink. a maximum depth Dpk, and a number Nk wherein k=1, 2, 3, . . a prefers that an index Dst of overall dimple surface area given by the following equation is at least 4.0, more preferably 4.0 to 7.0.

Note that R is a ball radius, Vo is as defined above, and NK is the number of dissples k. The index Dst of overall dimple surface mea is useful in optimizing various dimple parameters so as to allow the golf ball of the invention having the above-mentioned solid core and cover to travel a further distance. When the index Dat of overall dimple surface area is equal to or greater than 4.0, the serodynamics (flying distance and flight-in-wind) of the golf ball are further enhanced.

The multi-piece solid golf ball of the invention is improved in flying distance, controllability, roll and straight travel upon putting and is less susceptible to scraping upon bron shots.

EXAMPLE

Examples of the present invention are given below together with Comparative Examples by way of illustration and not by way of limitation.

Examples and Comparative Examples

By kecading a cone stock at shown in Table 1 and vulcanizing it in a mold at 160° C. for about 18 minutes. there were prepared solid cores having a weight, diameter. specific gravity and distortion under a load of 100 kg as shown in Table 4.

Golf balls were then obtained by separately kneeding an outer cover stock as shown in Table 2 and an inner cover stock as shown in Table 4 and forming them into half cups. successively placing the half cups around the core and effecting compression molding while forming dimples on the outer layer surface in a pattern as shown in Table 3. The parameters and performance properties of the resulting golf balls were examined, with the results shown in Table 4.

The properties of the golf balls reported in Table 4 were evaluated by the following tests.

Inertia Morocat

The diameter of the respective members was an average of diameters measured at arbitrary 5 points. As to weight, the

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ball was disintegrated into the respective members, which were measured for weight. The net weight and volume were calculated therefrom and the specific gravity of the respective members was calculated therefrom. The inertia moment was determined by substituting these values in the following organion.

- r,, D; core specific gravity, diameter
- r., D.: intermediate layer specific gravity, diameter
- r., D.: cover specific gravity, ball diameter

Flying Distance

Using a hitting machine manufactured by True Temper Co., the ball was actually hit at a head speed (HS) of 45 m/sec, with a driver to measure a carry and a total distance.

Scrape Resistance

Using a swing robot, the ball was hit at arbitrary two positions, once at each position, at a head speed of 38 m/sec. with a sand wedge (SW). The two hit zones were observed to evaluate according to the following criteria.

O: good A: ordinary X: poor

Continuous Durability

Using a flywheel hitting machine, the ball was repeatedly hit at a head speed of 38 m/sec. In terms of the number of hits counted until the ball was broken, evaluation was made according to the following criteria.

O: good A: ordinary X: poor

Feeling

The ball was actually hit by three professional golfers with a head speed of 45 to 50 m/sec. Evaluation was made according to the following criteria.

O: soft A: ordinary X: hard

30	R.	12	

34 100						
Core formulation (phw)	Fü	B 2	E3	E4	CEI	4
	1130	190	190	100	90	
Cis-1,4-polyheinGetm Polyhequen		_	,—		10	
Zanc narybus	32.5	32.5	29.5	23,0	24 42	

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TABLE 1-continued

5	Core formulation (plw)	Bl	E2	<u> 13</u>	E4	CEI
	The oxide	9.2	10.5	8.5	16.2	146
	Dienceyl perceide	1.2	1-2	1.2	1.7	1,2
	Zine salt of pentachlorothlophened	9.7	0.2	0.7	12.2	
^						

TABLE 2

15		0	ster co	ect this	
	Famulation (plw)	٨		В.	c
	PANDEX T-7890*1	100		-	
30	PANDEX T-1198+2		1	99	
	HIMILAN 1706*3				50
	\$URLYN 8130*4				50
	BiSO, (5.3. 4.47)				20
25	TiO ₂ (s.g. 43)	5.3		5.3	5.3
	Megnocium steatur	೧೨	*	0.3	0.5
	Specific gravity	1.175		1,21	1.13

- *IDui-Nikou ibk Chemical Industry K.K., adipute polyoi, therapolastic polyonethate
 *2Dui-Nikou ibk Chemical Industry K.K., adipute polyoi, therapolastic
- bolymegane
- *35-Euci-duPost X.X., Za imourer
- 35 *AE. L deffors, No soft innuner

TABLE 3

40	Dhaple	Dimmeter (assu)	Depth (mm)	٧,	Number	Surface conspation (%)	likst
•		4,100	0.210	0.500	54	68.7	4.137
	•	3.850	0.210	0.500	174	•	
		3,400	0.210	0.500	132		
	Ħ	4.150	0.210	0.490	54	70.3	4.D63
45	~	3.550	0.210	0,460	174		
		3,500	0.210	0.490	132		
	Ħ	3,650	0.195	0.390	150	62.7	1,961
	-	3,500	0.395	0,390	210		

TABLE 4

	·	B1	22	E3	B4	CEI	CS2	CE3
	****	25.44	29.02	26.19	27.10	33.53	25,44	14.69
Cite	Weight	35.50	37.00	36.00	36.00	38.70	33.50	27.70
	Deserver			2.60	3.30	2.50	2.20	4.00
	Discrios under	2.20	2.20	4.00	3470	وحيسيد		
	100 kg load Welsing	23.43	26.52	24.43	24.43	30.35	23.43	11.13
		1.086	L094	1,072	1.109	1.305	1.066	1.320
	Specialic gravity				Ъ		2	
Euror	Type *5		*	*	12.84		33,20	34.52
COVEC	Woight (g)	33,20	35,98	32.84				38.30
	Discovered (case)	38.75	39.70	38.75	38.73	*******	38,75	
	Volume	7.04	6.24	6.04	6.04	***	7.04	18.20
	Specific starity	1.102	1.302	1.102	0.950	***	1.102	1.103
	(Lickes)							
	Net weight	7.76	68.8	6.65	3.74	•	7.76	20.15
			1.35	1.38	1.38		1.63	5,30
	Fare	1.53	4.45	1,,24				

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TABLE 4-continued								
1 harr	Туре	٨	A	В	В	C	A	Ð
COYEF	Vojuzne	10.30	8,00	10.30	10.30	(C.4)	10.30	11.33
	No weight fgs	32.20	9.40	12.46	12,45	11.77	12.10	10.73
	Specific gravity	1.175	1.175	1,210	1.210	1.130	1.175	Đ.950
	Cingo (203)	3.98	1.50	1.99	1.98	2,08	1.98	2.10
	Shore D bardness	45	45	53	53	\$\$	45	65
Bali	Weight (g)	45.30	43.30	45.30	45,30	45.30	45.30	45.30
	Diameter (tum)	42,70	42.70	42.70	42,70	42.70	42.70	42,78
Increis movement		35,2	85.0	85.8	84.8	84,5	85.2	80.5
***************************************	Mer.	88.4	88.4	89.0	200	39. 2	88.4	90.0
	Mea	81.4	61.4	82.0	\$2.0	12.2	81.4	83.0
Dimels type		1	Ħ	1	B	1	111	. 1
Figure distance	Carry (co)	134.5	185.2	185.7	145.5	180.3	(77.0	183.0
OHS40	Total (m)	198.6	199.0	2000	200.5	195.7	191,5	197.5
Screen maintain		0	Ö	O	Çi	ж	•	Ç.
Continuous day		ģ	Š	ò	8	à	Ĉ.	ŝ
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HYTREL 4047	100	
HIMILAN IXX		\$0 50

We claim:

 A multi-piece solid golf ball comprising a solid core and a cover of at least two layers eaclosing the core and baying a number of dimples in the surface of a cover outer layer, wherein

said solid core is formed of a rubber base and has a specific gravity of at least 1.00.

said cover is formed of a thermoplastic resin and the cover outer layer has a greater specific gravity than the core and a cover inner layer,

the golf bell has an inertia moment (M) within the range given by the following expression:

и_мбиби_{м.}

wherein $M_{1/2}$ =0.08D+84.8 and $M_{2/2}$ =0.08D+77.8 wherein D is a Shore D hardness of the cover.

the dimples occupy at least 60% of the ball surface.

and V₀ which is the ratio of the volume of the dimple space below a plane circumscribed by the dimple edge to the volume of a cylinder whose bottom is the plane and whose height is the maximum depth of the dimple ⁴⁵ from the bottom is in the range of 0.4 to 0.65.

2. The multi-piece solid golf ball of claim I wherein said solid core experiences a distortion of 2.0 to 5.0 mm under a load of 100 kg.

3. The multi-piece solid golf ball of claim 1 wherein n types of dimples are formed in the cover, the respective types of dimples have a diameter Dank a maximum depth of the dimples is Dpk, and a number of the dimples is Nk wherein ke-1, 2, 3, and

an index (Det) of overall dimple surface area given by the following expression:

wherein R is a ball radius. Nik is the number of dimples k. 40 and V_o, is as defined above is at least 4.0.

4. The multi-piece solid golf ball of claim I wherein said cover outer layer has a Shore D hardness of 40 to 66.

5. The multi-piece solid golf ball of claim 1 wherein said cover outer layer is formed of a polyanethane elastosner.

EXHIBIT D

Paul Hastings

Paul, Hastings, Janotsky & Walker LLP 875 15th Street, N.W. • Washington, DC 20005 telephone 202 551 1700 • facsimile 202 551 1705 • www.paulhastings.com

Atlanta Beijing Brussels Hong Kong Landon Los Angeles Milan New York Drange County Palo Alto Paris San Diego San Francisco Shanghai Stamford Tokyo Washington, DC (202) 551-1754 brandonwhite@paulhastings.com

September 13, 2006

70416.00002

VIA FACSIMILE TO (202) 383-6610

Brian S. Seal, Esq. Howrey LLP 1299 Pennsylvania Ave., N.W. Washington, DC 20004

Re: Bridgestone Sports v A cushnet

Dear Brian:

1. Acushnet's Second Notice, Topics 1-4

In response to your letter of September 11, 2006, no witness will be provided for Topics 3-4 of Acushnet's Second Notice. The Altus Newing Massy is not asserted against claim 1 of the '707 patent' or claim 1 of the '834 patent.² Accordingly, no witness will be provided on Topics 3-4 of the Second Notice.

With respect to Topics 1-2 of Acushnet's Second Notice, Mr. Higuchi will be made available on October 9 with respect to these Topics. Even with interpretation, we believe that this is substantially more time than necessary for one golf ball asserted as prior art against only one claim of only one patent.

2. Reygrande WF 432

In response to the last paragraph of Drew Sommer's letter of September 8, 2006, Bridgestone will stipulate that the Reygrande WF 432 golf ball has 432 dimples.

3. Personal Deposition of Mr. Kasashima

Mr. Kasashima will be made available for his personal deposition on October 5-6, 2006.

¹ Acushnet's Supplemental Responses to Bridgestone's First Set of Interrogatories Directed to Acushnet (Nos. 1-24), dated May 1, 2006, at A-177 to A-187.

² Acushnet's Supplemental Responses to Bridgestone's First Set of Interrogatories Directed to Acushnet (Nos. 1-24), dated May 1, 2006, at A-380 to A-393.

Brian S. Seal, Esq. September 13, 2006 Page 2

Personal Deposition of Mr. Egashira, Acushnet's Second Notice, Topics 7-8 & Acushnet's Ninth Notice, Topics 1-5 4.

We previously scheduled Mr. Egashira's personal deposition on September 28-29. Mr. Egashira will also be made available on Wednesday, September 27 and, if necessary on Monday, October 2. The additional two days are intended to allow you to finish your questioning of the witness with respect to Topics 7-8 of Acushnet's Second Notice and Topics 1-5 of Acushnet's Ninth Notice. We believe this is more than ample time to cover these Topics. We do not intend to make the witness available on these Topics beyond these dates.

Please let me know if you have any questions.

Sincerely,

Brandon M. White

Bronatato

for PAUL, HASTINGS, JANOFSKY & WALKER LLP

Document 282-2

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Paul Hastings

Paul, Hastings, Janofsky & Walker LLP 875 15th Street, N.W. - Washington, DC 20005 telephone 202 551 1700 - tacsimile 202 551 1705 - www.paulhastings.com

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EXHIBIT E

Sep-29-06 04:50pm From-HOWREY SIMON + T-217 P.02/04 F-313

HOWREY

1299 Pennsylvania Avenue, NW Washington, DC 20004-2402 T 202,783 0800 F 202 383 6610 www.howrey.com

> Direct Diai 202 383.5904 File 00634.0002

September 29, 2006

BY FACSIMILE

Brandon M. White, Esq. Paul, Hastings, Janofsky & Walker LLP 875 15th Street, N.W. Washington, D.C. 20005

Re: Bridgestone Sports Co. v. Acushnet Co.,

C.A. No. 05-132 (JJF) (D. Del.)

Discovery Matters Raised in Your Letter of September 23

Dear Brandon:

Thank you for your letter of September 23. We respond herein to the issues you raised.

A. Production of Updated Sales and Cost Information

Acushnet agrees to exchange by November 15, 2006 updated sales and cost data for the period ending September 30, 2006.

B. Acushnet's Deposition Notices

We take issue with your decision not to make a witness available on topics 3 and 4 of Acushnet's Second Notice of 30(b)(6) Deposition, which relate to the Altus Newing Massy golf ball. As you are aware, you previously offered a witness for August 31-September 1 on topics 1-4 of that notice, as well as topics from Acushnet's Fourth and Fifth Notices. (See White Ltr. to Seal, Aug. 9, 2006, at 2.) That witness turned out to be Mr. Higuchi, who was deposed on the topics from the latter two notices. (See, generally, Higuchi Dep., Vol. 1 (Aug. 31, 2006) and Vol. 11 (Sep. 1, 2006).)

When it became apparent that we did not have time to complete Mr. Higuchi's deposition on the full set of topics from all three notices, we ended the second deposition at 4:45 p.m. At that time, however, Andrew Sommer informed Mr. Evans of your firm that we did so with the understanding that we would complete Mr. Higuchi's deposition on the remaining 30(b)(6) topics when he returned for his personal deposition which, at that time, was scheduled for September 28-29. (See White Ltr. to Seal, Aug. 11, 2006.) You later changed the dates for Mr. Higuchi's personal deposition to October 5-6. (See White e-mail to Grimaldi and Seal, Aug. 18, 2006.)

AMSTERDAM BRUSSELS CHICAGO EAST PALO ALTO HOUSTON IRVINE LONDON LOS ANGELES NORTHERN VIRGINIA PARIS SALT LAKE CITY SAN FRANCISCO TAIPEI WASHINGTON, DC Sep-29-06 04:50pm From-HOWREY SIMON T-217 P.03/04 F-313

HOWREY.

Brandon M. White, Esq. September 29, 2006 Page 2

It now appears that Bridgestone has taken advantage of Acushnet's inability to complete Mr. Higuchi's deposition on August 31-September 1 - on topics from three separate notices and the intervening delay to withdraw its previous offer to make him available on topics 3-4 from Acushnet's Second Notice. In light of our agreement to end his prior deposition with the understanding that he would subsequently be made available on the remaining topics, your unilateral withdrawal of the witness would be highly prejudicial to Acushnet. In particular, we believe that the Altus Newing Massy golf ball may be relevant to issues relating to the '817 patent - a belief we cannot confirm without additional discovery, including the deposition of a Bridgestone witness on topics 3-4. If you intend to maintain your refusal to provide a witness on topics 3-4 of Acushnet's Second Notice, please let me know your availability for a meet and confer on this question at your earliest convenience.

In addition, we take issue with your decision to make Mr. Higuchi available for only one day on topics 1-2 of Acushnet's Second Notice. Our request that you reserve his availability for a second day was based on accommodating Bridgestone's witnesses and attempting to ensure that Mr. Higuchi need not make another trip to the United States to complete his deposition. In any event, we are willing to start the deposition early and go later into the day, in the hopes that we can complete the deposition that day. We cannot guarantee that we can do so, however, particularly considering the delays caused by Bridgestone's insistence on translation of every question, answer and objection for its Japanese-speaking witnesses. Thus, should we not complete the deposition in the one day allotted by Bridgestone, we reserve the right to call him back for continued deposition.

We have a similar objection to the limitations you place on the deposition of Mr. Egashira. (See White Ltr. to Seal, Sep. 13, 2006, at 2.) As with Mr. Higuchi, we will make every effort to complete Mr. Egashira's depositions in the time allotted. If, however, we are unable to do so, we reserve the right to call him back for additional testimony.

Bridgestone's 11th Notice of 30(b)(6) Deposition C.

We expect to provide a written response early next week identifying the samples produced by Acushnet as AB 87866-87918. I note, however, that we have similar questions regarding your recent production of samples of BR 11 and BR 18. Given your prior representations that Bridgestone did not have any such samples of BR 11 in its possession and that JSR had stopped manufacturing BR 11, we would like to know where both samples were located, when they were manufactured, and how they were stored prior to production to Acushnet. Please let me know whether you agree to provide that information in writing or whether a deposition will be necessary.

Sep-29-06 04:51pm From-HONREY SIMON

T-217 P.04/04 F-313

Brandon M. White, Esq. September 29, 2006 Page 3

D. Deposition of Mr. Nagasawa

With regard to your fourth paragraph, we hope to confirm early next week whether we can depose Mr. Nagasawa on October 18-19.

Regards,

Brian S Seal

Sep-29-06 04:50pm From-HOWREY SIMON

T-217 P.01/04 F-313



1299 PENNSYLVANIA AVENUE, N.W. WASHINGTON, DC 20004-2402 PHONE: 202.783.0800 • FAX: 202.383.6610

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